

MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION
General Certificate of Education Ordinary Level

CANDIDATE
NAME

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CENTRE
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INDEX
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Paper 3 Chemistry

October/November 2021

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.

You may use an HB pencil for any diagrams, graphs, tables or rough working.

Write in dark blue or black pen.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

DO NOT WRITE ON ANY BARCODES.

Section A

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

Section B

Answer any **two** questions.

Write your answers in the spaces provided on the question paper.

A copy of the Data Sheet is printed on page 19.

A copy of the Periodic Table is printed on page 20.

The number of marks is given in brackets [] at the end of each question or part question.

Section A

Answer **all** the questions in the spaces provided.

- 1 Choose from the following oxides to answer the questions.

calcium oxide
carbon dioxide
carbon monoxide
magnesium oxide
nitrogen dioxide
sulfur dioxide
water

Each oxide may be used once, more than once or not at all.

Identify an oxide which:

- (a) is basic

..... [1]

- (b) is neutral

..... [1]

- (c) causes acid rain

..... [1]

- (d) reduces iron ore in a blast furnace

..... [1]

- (e) is formed from the incomplete combustion of methane

..... [1]

- (f) reacts with impurities in the ore in a blast furnace to form slag.

..... [1]

[Total: 6]

- 2 Table 2.1 shows some information about the elements in Group I of the Periodic Table.

Table 2.1

element	atomic number	melting point/°C	density in g/cm ³
lithium	3	180	0.53
sodium	11	98	0.97
potassium	19	63	0.89
rubidium	37	39	1.53
caesium	55		

- (a) Predict the melting point of caesium.

..... °C [1]

- (b) Explain why it is more difficult to predict the density of caesium than the melting point of caesium using information from Table 2.1.

.....
.....
..... [1]

- (c) State one **other** physical property of caesium.

..... [1]

- (d) (i) Suggest why sodium is in period 3 of the Periodic Table.

.....
..... [1]

- (ii) Write the balanced chemical equation for the reaction between sodium and cold water.

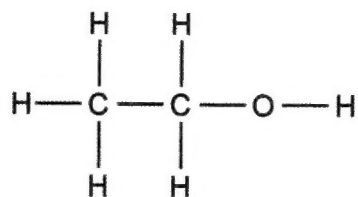
Include state symbols in your answer.

..... [3]

[Total: 7]

- 3 Ethanol is a member of the alcohol homologous series.

The structure of ethanol is shown.



- (a) State the number of atoms in one molecule of ethanol.

..... [1]

- (b) Ethanol is manufactured by the fermentation of glucose.

Briefly describe this process.

Include in your answer the conditions needed for fermentation and how the ethanol is purified.

.....
.....
.....
.....
.....
.....
..... [3]

- (c) Ethanol is oxidised by oxygen in the air to form ethanoic acid.

Draw the full structural formula of ethanoic acid. Show all the bonds in your answer.

[1]

(d) The general formula for the homologous series of saturated alcohols is $C_nH_{2n+1}OH$.

A compound has the molecular formula $C_7H_{13}OH$.

State whether the compound $C_7H_{13}OH$ is a saturated alcohol, and explain your answer.

.....

.....

.....

[1]

[Total: 6]

4 Table 4.1 when complete describes and names different types of reactions.

Complete Table 4.1.

Table 4.1

description of reaction	type of reaction
many monomers forming a polymer	polymerisation
large alkane molecules broken down into smaller alkene and alkane molecules	
acid reacting with base	
takes in energy, often in the form of heat, from the surroundings	
two solutions react to form an insoluble solid	
the oxidation state of an element increases	

[5]

- 5 Magnesium sulfate is a soluble salt prepared from an insoluble base and an acid.

Magnesium hydroxide is a suitable insoluble base.

Stage 1 – Excess magnesium hydroxide is added to the dilute acid. The mixture is stirred and warmed.

Stage 2 – The excess magnesium hydroxide is separated from the aqueous magnesium sulfate formed in stage 1.

Stage 3 – Aqueous magnesium sulfate is left in air to crystallise.

- (a) Name the acid used in stage 1.

..... [1]

- (b) Explain why **excess** magnesium hydroxide is used in stage 1.

.....

..... [1]

- (c) Suggest why the mixture is stirred and warmed in stage 1.

.....

..... [1]

- (d) Name the method of separation used in stage 2.

..... [1]

- (e) Name the physical change that occurs to water in stage 3 when magnesium sulfate is crystallised from its aqueous solution.

..... [1]

[Total: 5]

6 A scientist is analysing three samples of impure paracetamol, a pharmaceutical drug.

(a) Table 6.1 shows the melting point of these three samples.

Each sample contains the same impurity.

Table 6.1

sample	melting point/°C
A	165–167
B	167–169
C	168–169

Use information in Table 6.1 to state how the scientist knows that the three samples are impure.

..... [1]

(b) Use the kinetic particle theory to describe the changes in the movement and arrangement of particles during the melting of paracetamol.

movement

.....

.....

arrangement

.....

.....

[3]

(c) Suggest a reason why it is important that pharmaceutical drugs are tested for purity.

..... [1]

[Total: 5]

- 7 Fig. 7.1 describes some of the substances that result from the chemical reactions of barium carbonate.

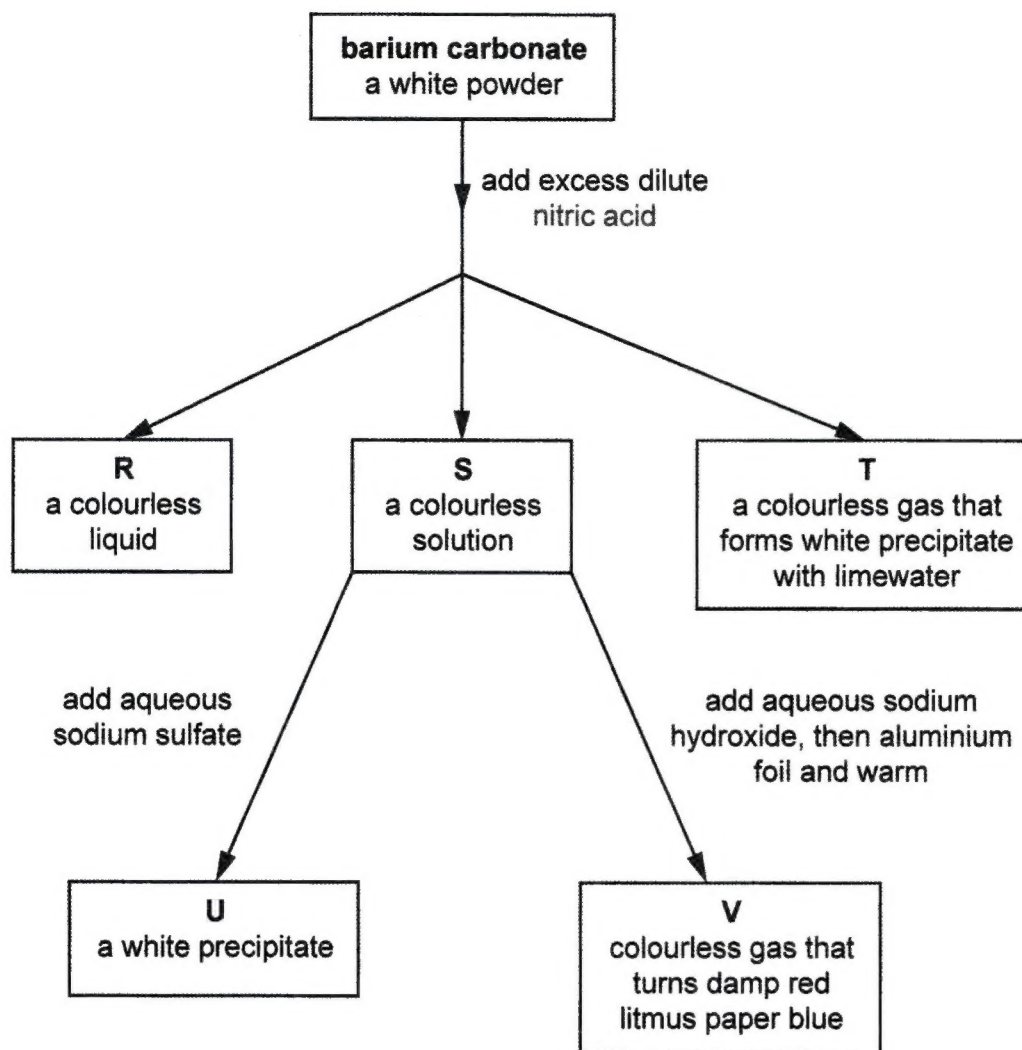


Fig. 7.1

- (a) Identify each of R, S, T, U and V.

R

S

T

U

V

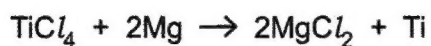
[5]

- (b) Write a balanced chemical equation for any of the reactions shown in Fig. 7.1.

..... [2]

[Total: 7]

- 8 Titanium is manufactured by the reduction of titanium(IV) chloride by magnesium.



- (a) Calculate the maximum mass of titanium that will be made from 9.50 g of titanium(IV) chloride.

[Relative atomic masses: A_r : Mg, 24; Cl, 35.5; Ti, 48]

mass of titanium = g [2]

- (b) Titanium is often used to make alloys.

Give the meaning of the term *alloy*.

.....
.....
..... [1]

- (c) Name an example of an alloy.

..... [1]

[Total: 4]

Section B

Answer any **two** questions from this section.

Write your answers in the spaces provided.

9 Zinc reacts with dilute hydrochloric acid to form hydrogen gas.

(a) In an experiment 0.500 g of zinc is reacted with 25.0 cm³ of 0.150 mol/dm³ hydrochloric acid.

The total volume of hydrogen produced every 50 s is measured.

Fig. 9.1 shows a graph of the results.

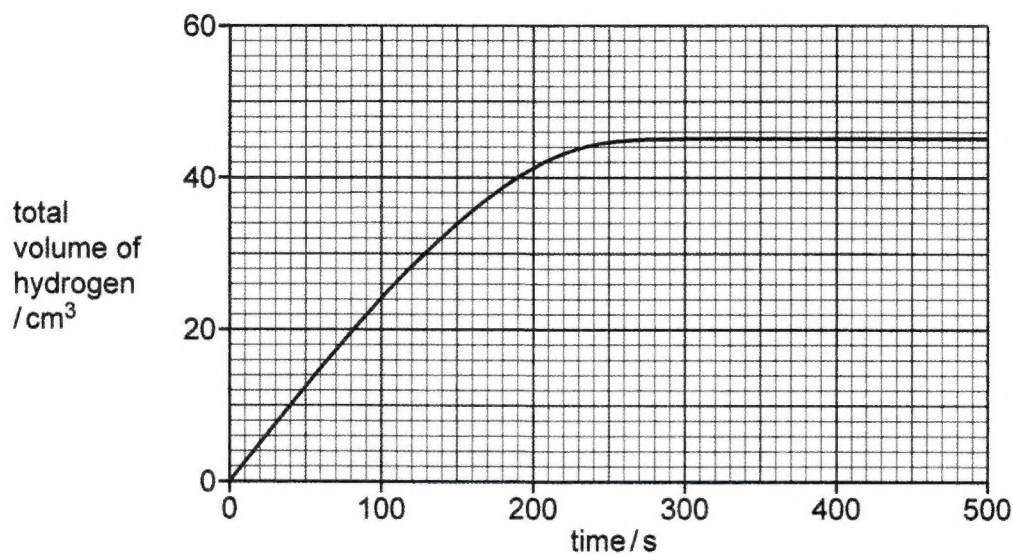


Fig. 9.1

(i) State the time when the zinc and hydrochloric acid first stop reacting.

..... s [1]

(ii) Draw a labelled diagram showing the set up of apparatus that can be used to collect and measure the volume of gas produced in the experiment.

[2]

- (iii) The experiment is repeated using an **increased** temperature of acid.

The quantities of the reactants used are the same.

Draw a curve on Fig. 9.1 to show the results of this experiment.

Label this curve **X**.

[2]

- (iv) The experiment is repeated a second time. This time the concentration of the hydrochloric acid is **decreased**.

Explain why the initial rate of the reaction decreases.

.....
.....
..... [2]

- (b) In a different experiment 1.00 g of zinc (an excess) is reacted with 50.0 cm³ of 0.400 mol/dm³ hydrochloric acid.



- (i) Calculate the number of moles of hydrochloric acid, HCl, that reacts.

number of moles = mol [1]

- (ii) Calculate the number of moles of hydrogen, H₂, formed.

number of moles = mol [1]

- (iii) Calculate the volume of hydrogen, H₂, formed at room temperature and pressure.

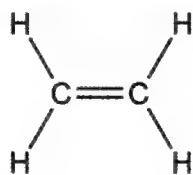
[The volume of one mole of any gas is 24 dm³ at room temperature and pressure.]

volume = dm³ [1]

[Total: 10]

10 The alkenes are a homologous series of unsaturated hydrocarbons.

The structure of ethene, the first member of the alkene homologous series, is shown.



(a) Use the structure to explain why ethene is unsaturated.

.....
..... [1]

(b) Describe a chemical test to show that ethene is unsaturated.

.....
.....
.....
..... [2]

(c) Draw a 'dot and cross' diagram to show the bonding in a molecule of ethene.

Show only the outer shell electrons.

[2]

(d) Ethene is used to make the addition polymer poly(ethene). Poly(ethene) is a non-biodegradable plastic.

(i) Draw the full structural formula of two repeating units of poly(ethene). Show all the bonds in your answer.

[2]

(ii) Poly(ethene) has many uses.

State **one** use for poly(ethene).

..... [1]

(iii) Describe some of the pollution problems caused by the disposal of poly(ethene).

.....
.....
.....
.....
..... [2]

[Total: 10]

11 One of the isotopes of bromine has the symbol shown.



- (a) (i) Complete Table 11.1 to show the relative mass and relative charge of the particles found in this isotope.

Table 11.1

particle	relative mass	relative charge
electron		
proton		1+
neutron	1	

[2]

- (ii) Determine the number of each of these particles found in one atom of this isotope.

electrons

protons

neutrons

[3]

- (iii) An atom of another isotope of bromine has twice the number of nucleons as one atom of ${}^{40}_{20}\text{Ca}$.

Deduce the number of neutrons present in an atom of this isotope of bromine.

..... [1]

- (b) Potassium bromide is an ionic compound.

- (i) Potassium bromide contains potassium ions, K^+ , and bromide ions, Br^- .

Describe the formation of these potassium ions from potassium atoms in terms of electron configuration.

.....

 [2]

- (ii) State **two** physical properties of potassium bromide.

1.
 2.
 [2]

[Total: 10]

Section A

1. (a) calcium oxide or magnesium oxide

EXAM TIP:

Metals usually form basic oxides.

- (b) carbon monoxide or water

EXAM TIP:

Carbon monoxide, nitrogen monoxide and water are examples of neutral oxides that we learn in the syllabus.

- (c) nitrogen dioxide or sulfur dioxide

EXAM TIP:

Acidic gases such as nitrogen dioxide and sulfur dioxide dissolve in water in the atmosphere to form acid rain.

- (d) carbon monoxide

EXAM TIP:

Carbon monoxide reduces iron ore (iron(III) oxide) to iron.

- (e) carbon monoxide

EXAM TIP:

The incomplete combustion of hydrocarbons such as methane will form carbon monoxide (or carbon) and water.

- (f) calcium oxide

EXAM TIP:Calcium oxide reacts with impurities such as silicon dioxide to form molten slag (CaSiO_3).

2. (a)
- 28°C

(any value below 39°C and above room temperature is acceptable)**EXAM TIP:**

The melting point of Group 1 elements decreases down the group.

- (b) Down the table, the melting point of the elements decreases consistently from
- 180°C
- in lithium to
- 39°C
- in rubidium.

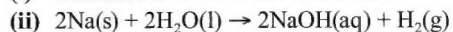
On the other hand, the density of the elements generally increases down the table, with the exception of potassium, which has a lower density than sodium. This makes it harder to predict the trend in the density of the elements.

- (c) Good conductor of electricity
-
- (Other acceptable answer: soft)

EXAM TIP:

Group 1 elements are metals with relatively low melting points, are good conductors of electricity and are relatively soft.

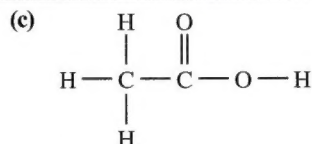
- (d) (i) Sodium atom has 3 electron shells.

**EXAM TIP:**

The number of electron shells in an atom of an element that is occupied with electrons indicates the period of the Periodic Table.

3. (a) 9 atoms

- (b) The fermentation of glucose is a process in which yeast acts on glucose in the absence of oxygen to produce ethanol and carbon dioxide. During fermentation, the temperature is kept at around
- 37°C
- . Pure ethanol can be obtained by fractional distillation.

EXAM TIP:Ethanol is produced from the fermentation of glucose in the presence of yeast at 37°C .**EXAM TIP:**

Ethanoic acid is a carboxylic acid with two carbon atoms.

- (d)
- $\text{C}_7\text{H}_{13}\text{OH}$
- is not a saturated alcohol. The formula of a saturated alcohol with 7 carbon atoms (
- $n = 7$
-) is
- $\text{C}_7\text{H}_{15}\text{OH}$
- , which is different from the compound
- $\text{C}_7\text{H}_{13}\text{OH}$
- .

EXAM TIP:

Compare the number of hydrogen atoms in the general formula of a saturated alcohol with the actual molecular formula of the compound to determine whether the compound is a saturated alcohol.

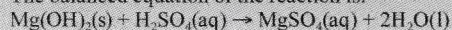
- 4.

description of reaction	type of reaction
many monomers forming a polymer	polymerisation
large alkane molecules broken down into smaller alkene and alkane molecules	cracking
acid reacting with base	neutralisation
takes in energy, often in the form of heat, from the surroundings	endothermic
two solutions react to form an insoluble solid	precipitation
the oxidation state of an element increases	oxidation

5. (a) sulfuric acid

EXAM TIP:

The balanced equation of the reaction is:



- (b) Excess magnesium hydroxide is used to ensure all the acid is reacted completely with the magnesium hydroxide.
- (c) The mixture is stirred and warmed to increase the speed of reaction.
- (d) Filtration

EXAM TIP:

By adding excess magnesium hydroxide to dilute sulfuric acid, only MgSO_4 and excess Mg(OH)_2 solid will remain in the mixture, in which Mg(OH)_2 can be removed by filtration.

- (e) Evaporation

EXAM TIP:

Water is evaporated when magnesium sulfate is crystallised from its aqueous solution.

6. (a) They are impure as they have a range of melting points.
- (b) movement: Changes from vibrating at fixed positions to sliding past one another.
arrangement: Changes from regularly arranged to irregularly arranged.

EXAM TIP:

The table below summarises the movement and arrangement of particles in solid, liquid and gaseous states.

	Solid	Liquid	Gas
Movement	Vibrate at fixed positions only	Move about within confined space and slide past one another	Move freely in all directions at high speed
Arrangement	Regular structure and vibrate at fixed positions	Irregular and random	Irregular and random

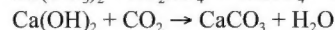
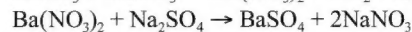
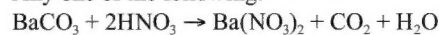
- (c) To ensure that there are no harmful substances in the drugs.

EXAM TIP:

Impurities in drugs may be harmful to human bodies.

7. (a) R: water
S: barium nitrate
T: carbon dioxide
U: barium sulfate
V: ammonia

- (b) Any one of the following:



EXAM TIP:

Acids react with carbonates to form salt, carbon dioxide and water.

Ba^{2+} ions react with sulfate ions to form a white precipitate of BaSO_4 .

Limewater is used to test for the presence of carbon dioxide.

8. (a) Number of moles of $\text{TiCl}_4 = \frac{9.50}{48 + 35.5 \times 4} = 0.05 \text{ mol}$

Since 1 mole of TiCl_4 produces 1 mole of Ti,

number of moles of Ti = 0.05 mol

Mass of Ti produced = $0.05 \times 48 = 2.4 \text{ g}$

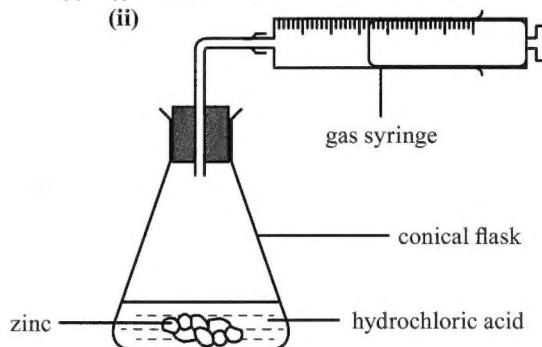
EXAM TIP:

$$\text{Number of moles of a substance} = \frac{\text{Mass}}{\text{Molar mass}}$$

- (b) Alloy is a mixture of metal and one or more elements.
- (c) Steel
(Other acceptable answers: stainless steel, brass or bronze)

Section B

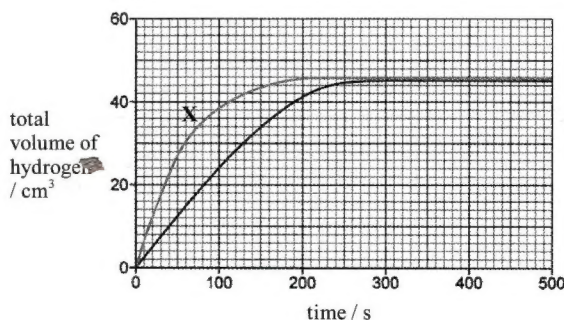
9. (a) (i) 270 s
(ii)



EXAM TIP:

Gas syringe is used to collect and measure the volume of gas produced.

- (iii)



- (iv) When the concentration of the reactant decreases, the number of reacting particles per unit volume decreases. This will lower the frequency of effective collisions and thus the initial rate of reaction decreases.

EXAM TIP:

The rate of reaction depends on the frequency of effective collisions.

(b) (i) Number of moles of $\text{HCl} = 0.400 \times \frac{50.0}{1000}$
 $= 0.0200 \text{ mol}$

EXAM TIP:

Number of moles = Concentration \times Volume

- (ii) Since 2 moles of HCl produce 1 mole of H_2 , number of moles of H_2 formed
 $= 0.0200 \div 2$
 $= 0.0100 \text{ mol}$

(iii) Volume of H_2 formed $= 0.0100 \times 24$
 $= 0.240 \text{ dm}^3$

EXAM TIP:

Volume (dm^3) = Number of moles \times Molar volume

10. (a) Ethene is an unsaturated molecule as it possesses a carbon-carbon double bond.

EXAM TIP:

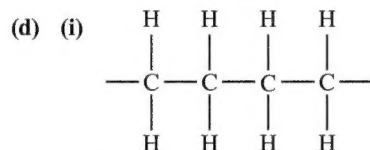
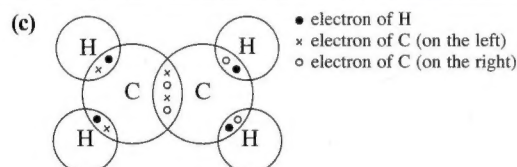
Unsaturated compound contains at least one carbon-carbon double bond.

- (b) Add the sample of ethene into a test-tube of aqueous bromine.

The aqueous bromine will turn from reddish-brown to colourless, indicating that ethene is unsaturated.

EXAM TIP:

Aqueous bromine is used to test for the presence of unsaturated compounds.



EXAM TIP:

In the addition polymerisation of ethene, the unsaturated ethene molecules join to form a very large molecule without losing any atoms.

- (ii) Plastic bag
 (Other acceptable answer: clingfilm)

- (iii) Any two of the following:

- As plastics do not decompose, burying plastic waste in landfills leads to an increasing amount of built-up waste and causes land pollution.
- Combustion of plastic may produce poisonous gases which causes air pollution.
- Plastics in the sea endanger marine life as they might be mistaken for food and they clog up rivers.

EXAM TIP:

As poly(ethene) is non-biodegradable (cannot be broken down by bacteria), disposal of poly(ethene) leads to buildup of waste in land and water.

11. (a) (i)

particle	relative mass	relative charge
electron	$\frac{1}{1840}$	1-
proton	1	1+
neutron	1	0

- (ii) electrons: 35
 protons: 35
 neutrons: 44

EXAM TIP:

The chemical symbol of an element is ${}_Z^AX$, where A is the nucleon number and Z is the proton number.

Nucleon number = number of protons + number of neutrons

- (iii) Number of nucleons in the isotope of bromine $= 40 \times 2 = 80$

Number of neutrons in the isotope of bromine $= 80 - 35 = 45$

- (b) (i) The electronic configuration of potassium is 2,8,8,1. It loses one electron in its valence shell to form potassium ion (K^+), in order to obtain a stable electronic configuration.

EXAM TIP:

Metal ions lose electrons to form a cation with a stable electronic configuration.

- (ii) Any two of the following:

- Able to conduct electricity in molten and aqueous states
- Soluble in water
- High melting and boiling points

EXAM TIP:

Ionic compounds have high melting and boiling points, are good conductors of electricity and are usually soluble in water.